

# Developing Methods for Managing Coyote Problems – Another Decade of Progress, 1991-2001

Michael W. Fall and J. Russell Mason

USDA APHIS Wildlife Services, National Wildlife Research Center, Fort Collins, Colorado

**Abstract:** The continued expansion of coyote activity to new areas, the growth and expansion of human populations, undiminished difficulties faced by livestock producers in managing predation, and highly polarized public values have challenged the abilities of a new generation of scientists and students to develop effective, socially acceptable predation management methods. Work by scientists at the National Wildlife Research Center, their students, and numerous cooperators has resulted in more than 150 research papers, reports, theses, and dissertations during the past decade, substantially increasing the body of knowledge of coyote management strategies and describing progress in the development of new management methods. Much of the effort has focused on research on non-lethal techniques, methods that are selective for individual problem animals, and procedures perceived by the public to be more humane. More than two-thirds of the predator research scientists now at the Center were hired during the past decade, bringing fresh perspectives and new talent to the pervasive problems of livestock predation by coyotes.

**Key Words:** attractants, aversive, baiting, capture, control methods, coyotes, fertility, predation, livestock, repellents

Proc. 20<sup>th</sup> Vertebr. Pest Conf. (R. M. Timm and R. H. Schmidt, Eds.)

Published at Univ. of Calif., Davis. 2002. Pp. 194-200.

## INTRODUCTION

Coyotes are a major predator of livestock throughout the United States, despite extensive continuing efforts by landowners, state agencies, and USDA's Wildlife Services to manage predation losses. The tools available to producers and wildlife managers are increasingly being limited by changes in laws and regulations, by policies of land management agencies, and by court actions by special interest groups. In addition, because of reduced coyote population management by states through regulated trapping and hunting, coyote range expansion and movement into new habitats has continued. Management of predation losses continues to be a difficult challenge for thousands of livestock producers (Timm and Connolly 2001, Bodenchuk et al. *In Press*) and researchers continue to face the critical need to improve existing management methods and devise new ones.

For many decades, much of the research on methods development for managing livestock predation was conducted and financed by the federal government. The Denver Wildlife Research Center, along with its predecessor laboratories, was virtually synonymous with these efforts. As described by Balser (1974), federal research on coyote control methods from 1930 to 1960 was largely conducted by one or two individuals, with primary work on coyote food habits, the coyote-getter, and large bait stations. Attempts were made during the 1960s to obtain information on coyote population dynamics and the effects of control programs (Knowlton 1972), fertility control (Balser 1964, Linhart et al. 1968), and tranquilizers for use with traps (Balser 1965).

Following successful efforts in the early 1970s by U.S. Department of Interior officials to terminate predator control activities, a new major research effort began in the

mid-1970s with the provision of funding to establish a predator research group at the Denver Wildlife Research Center. It was envisioned that this group would "conduct an expanded research program to learn more about predator-prey relationships; develop better, more selective, humane control methods; and get a better idea of what actual predator-caused losses of livestock really are..." (Reed 1972). Responsibility for direct predator control was to be delegated to the states under a block grant scheme. New scientists were hired, several new field stations were established, and the effort to discover selective and non-lethal management methods was launched. This effort was not fully successful, since the Fish and Wildlife Service, which then administered the research program, failed to allocate adequate and reliable funding. Many of Reed's (1972) initial objectives for research were slowly accomplished: empirical studies showed that livestock predation was economically significant and not imagined by ranchers (to the consternation of animal rights supporters), coyote population ranges continued to expand, and the non-lethal methods available were not stand-alone techniques that could be uniformly effective.

Much of the work on non-lethal predation management accomplished during this period was described by Linhart (1984), including studies of electric fencing, livestock guarding dogs, chemical repellents and aversive agents, and frightening devices. The effectiveness of livestock husbandry practices was also investigated. However, the most selective or site-specific techniques to emerge during this period – toxicant-containing collars, toxicant ejectors, coyote den fumigation, and aerial hunting – were all lethal, and their development, evaluation, registration, re-registration, and maintenance occupied much of the time and funding of

the research group for the next decade. Although federal responsibility for managing predation using restricted lethal techniques was soon re-established, research funding remained static.

By 1985, with the transfer of Wildlife Services to the U. S. Department of Agriculture - Animal and Plant Health Inspection Service, research facilities at the Denver Wildlife Research Center were decrepit, no new scientists had been hired nearly a decade, and 95% of the available funding was devoted to facilities maintenance and salaries. Most of the Center's field stations established to research non-lethal predation control methods had been closed to recover operating funds for the research program.

From 1986 to 1990, research focused primarily on maintaining existing tools, as directed by Congress. Progress was also made in analyzing work from previous studies (which proved possible with minimal funding), and in completing the registration process, updates, and label changes for predation management products, such as the carbon monoxide cartridge, the Livestock Protection Collar (LPC), and the M-44 cyanide ejector (Fall 1990).

Our purpose here is to summarize changes in Wildlife Services predation management research program during the past decade and to highlight recent research in several areas that may improve the ability of livestock producers and wildlife managers to address the problems of predation in socially acceptable ways.

#### **FACILITIES, PROGRAM, AND STAFF**

The National Wildlife Research Center (NWRC) was established in 1996 by Wildlife Services within the USDA - Animal and Plant Health Inspection Service. This new institution subsumed the Denver Wildlife Research Center, its personnel, field stations, and facilities. Curnow (1996) described plans for the establishment of the NWRC's new headquarters facilities on a 43-acre site at Colorado State University. During the past several years, modern animal research and laboratory/office buildings have been constructed on the site; 25 additional structures (animal pens, aviaries, and support buildings) are under construction. NWRC field station facilities have also improved, most notably including the completion of new buildings and pens at the Utah State University Field Station where a large outdoor research complex is maintained for studies of coyote behavior and predation management.

With the successful completion of much of the original charge to "maintain existing tools" (Fall 1990), and with new Congressional direction to develop new non-lethal management methods, the focus of the research program changed. Retirement of research staff that had joined the Center during the late 1960s and early 1970s provided opportunities for other scientists with fresh perspectives, new ideas, and diverse skills. More than two-thirds of the current NWRC predator research group was hired during the past decade. Work by this

group, their students, and numerous cooperators has resulted in more than 150 research papers, reports, theses, and dissertations, substantially increasing our understanding of coyotes and coyote problems, and describing progress in the development of new management methods. These papers represent more than one-third of all of the Center's publications related to predation management since the establishment of the original Denver Wildlife Research Laboratory in 1940. Support of student research at universities has been an important and productive aspect of the Center's research program for many years. Of particular importance has been the establishment of the Berryman Institute at Utah State University, bringing more opportunities for student participation in predation control research (Conover et al. 1991, Schmidt et al. 1992).

Although our space is limited, and recent reviews of predation management research on methods and strategies are available (for example, Knowlton et al. 1999, Rollins et al. 1995, Mason et al. 2001), we will summarize recent progress in several areas, based primarily on the work of our colleagues and cooperators at the National Wildlife Research Center.

#### **COYOTE BAITS, LURES, AND ATTRACTANTS**

Considerable work has been conducted in the past 15 years on bait delivery methods for coyotes - initially to develop low-density bait applications for use with toxicants, later to develop delivery methods for use with vaccines. Linhart et al. (1997) provided a comprehensive review of much of the baiting research conducted before 1994 with coyotes and other species. Subsequently, we worked with collaborators to develop the bait formulation and attractants currently used to deliver recombinant rabies vaccine to coyotes and foxes in Texas and raccoons in the northeastern United States, and continue to collaborate with other organizations to develop modified and improved delivery systems for rabies vaccine. This work may prove to have important applications in livestock protection if efforts to find chemical or biological agents that can inhibit coyote reproduction by oral delivery are ultimately successful.

More recently, Mason and McConnell (1997) studied coyote response to a variety of tastes to determine materials that were highly preferred or rejected. They found that disaccharide sugars were strongly attractive while a number of other tastes were neutral or rejected, including a variety of salts and proteins. They also found that coyotes were uniformly insensitive to bitter with the exception of quinine hydrochloride. Windberg (1996), Mason and Burns (1997), and Mason et al. (1999) systematically investigated the potential for manipulating coyote bait acceptance by examining novelty and visual cues, and have applied this work to improve M-44 performance. For example, sweet baits colored to contrast with background coloration are attractive to coyotes (Mason et al. 1999). Use with this device might offer a way for selective delivery of contraceptive agents.

Efforts have also continued to more fully understand the use of odor attractants to obtain particular coyote responses (Phillips and Blom 1994) and development of standardized lures and slow-release formulations (Kimball et al. 2000, Mason and Blom 1998).

### **REPELLENTS AND AVERSIVE TECHNIQUES**

Over a number of years, our research group has investigated the effectiveness of many commercially available or candidate coyote deterrents. Recent studies include evaluation of capsicum collars (Burns and Mason 1996), chemical paints (Zemlicka and Mason 2000), and a variety of bittering agents (Mason and McConnell 1997). None of these have shown reliable aversive effects for protecting livestock. The only substance we have identified that is reliably aversive is d-pulegone, for which the NWRC was awarded a patent in 1999 (Mason et al. 1999). This mint-scented compound deters feeding and is effective because it is both irritating and causes post-ingestive malaise.

Recent studies have shown the effectiveness of aversive conditioning using electronic dog training collars to interrupt and prevent coyote attacks on domestic sheep (Andelt et al. 1999, Mason et al. 2001). These devices produce a mild electrostatic discharge when triggered by a radio signal. With one manufacturer, we constructed a sound-activated collar triggered by sounds of domestic animals in range situations (Shivik and Martin 2001). Given the potential for use with inexpensive auto-collaring devices (Shivik and Martin 2001), future application to coyotes and other predators is realistic (Shivik 2001, Shivik and Martin 2001).

NWRC scientists have shown that multi-stimulus frightening devices for coyotes can reduce predation in both pasture and open-range situations (Linhart et al. 1984, Linhart et al. 1992). The "Electronic Guard" manufactured by the Pocatello Supply Depot was very effective in stopping established patterns of predation for varying periods when used correctly (27-136 nights; Linhart et al. 1984). Recent testing indicates that behavior-contingent activation by a predator's approach or other behavior could substantially increase the effectiveness of frightening devices. Initial high costs of engineering and prototype production, however, may be prohibitive. Shivik, working with collaborators, has begun testing the concept as a means of protecting pastured calves from predation or harassment by wolves and bears. In the test situations, devices are triggered when a radio-collared animal approaches a protected pasture (Shivik 2001, Shivik and Martin 2001).

### **CAPTURE DEVICES**

We have made substantial progress in the development of alternatives to conventional capture devices. This has included research on improving performance of padded-jaw traps (Linhart and Dasch 1992, Phillips and Mullis 1996), evaluation of new pan tension systems to increase selectivity (Phillips and

Gruver 1996), registration of a tranquilizer and improved delivery system for use with capture devices (Zemlicka et al. 1997), remote monitoring systems for checking trap activity (Halstead et al. 1996), and development of new, cable restraint systems (Shivik et al. 2000). We are also investigating the feasibility of developing low-cost autocollaring devices for livestock predators (Shivik and Martin 2001). Such devices, using break-away snare technology, could radio-tag predators to allow direct monitoring or capture of specific problem animals. Auto-collaring devices might also have application in the future use of electronic training collars to prevent predatory attacks on livestock (Mason et al. 2001). Fall (2002) provides more discussion of this area of NWRC research.

### **COYOTE FERTILITY CONTROL**

Since the 1960s, developments in human fertility control have intrigued scientists searching for applications in predation management (Balser 1964, Linhart et al. 1968). A number of problems exist, some seemingly insurmountable, that make the approach difficult to apply to managing populations of widely distributed vertebrate pest species with high reproductive potential. During the past decade, new possibilities for immunological approaches to wildlife contraception, particularly the possibility of effective treatment of animals independent of stages in the reproductive cycle, led us to re-examine the possibilities for using this approach to manage coyote predation on livestock (Miller 1995). Following Till and Knowlton's (1983) demonstration that sheep predation declined by more than 90% when pups were removed from the territory of a coyote pair, Knowlton (1989) speculated on a strategy of sterilizing adult territorial animals. Knowlton envisioned coyote predatory behavior related to provisioning pups could be modified by sterilization if normal hormonal function remained intact. This strategy, as opposed to population management by sterilization, had some attractive advantages in greatly reducing the amount of material and logistics that might be required and, perhaps, in limiting areas of treatment to specific den sites in sheep production areas, simplifying a product registration. Working with a number of collaborators, we have examined surgical sterilization and immunological, hormonal, and chemical agents under pen conditions. Several materials appear to have promise, but none show sufficient promise such that rapid development could be anticipated.

Concurrently, we conducted a long-planned, large-scale field experiment to determine the actual effect of sterilization in reducing predation (Bromley and Gese 2001a,b). Coyotes were captured by netting from a helicopter. Territories and social status were determined using radio telemetry, then animals were randomly assigned to a surgical sterilization or reference groups and exposed periodically to sheep flocks. The results showed that sterile coyotes maintained territories and pair bonds and that they were less likely to prey on sheep than coyotes with pups. New coyotes were not successful in

establishing within the territories of sterilized animals. Interestingly, predation was reduced sufficiently that the cumbersome method of helicopter capture and surgical sterilization was cost-effective (Bromley and Gese 2001b). Although practical methods to sterilize animals in the field remain to be developed, NWRC scientists and collaborators continue to examine materials and options (DeLiberto et al. 1998).

## **DIFFERENTIAL BEHAVIOR AND VULNERABILITY TO CONTROL METHODS**

After the firm establishment in the 1970s and early 1980s that coyotes were indeed responsible for extensive livestock losses and that coyotes, far from being "endangered" by control programs in limited agricultural areas, were expanding their range in North America and beginning to occupy urban and suburban habitats, no questions have been more intriguing to predation scientists than determining "Which coyotes kill sheep?" and "How can they be identified?" Most biologists directly involved in research on predation control had long believed that differential behavior and territoriality were important to understanding how livestock predation might best be managed (Knowlton 1972, Connolly et al. 1976, Knowlton 1989). This underlying assumption was important for the development of selective techniques, including the Livestock Protection Collar or LPC (Connolly et al. 1978) and den hunting (Till and Knowlton 1983), and was supported by growing evidence that some coyotes were more vulnerable to control methods than others (Knowlton et al. 1985, Windberg and Knowlton 1988, Windberg and Knowlton 1990, Harris and Knowlton 2001).

During the past decade, cooperative research on coyote behavior, predation patterns, and use of control methods at the University of California's Hopland Research and Extension Center made important contributions to understanding these intriguing questions (Blejwas et al. 2002; Conner et al. 1998; Jaeger et al. 2001; Neale et al. 1998; Sacks et al. 1999a,b; Sacks and Neale *In Press*; Timm and Connolly 2001). Together, these studies showed that territorial, dominant coyotes, "alphas," are the principal killers of sheep; that younger, subordinate, or transient coyotes are more susceptible to a number of control methods; and that selective removal of dominant territorial coyotes with territories overlapping sheep ranges is an effective predation management strategy (Jaeger et al. 2001). Selective removal of "killer" coyotes using the LPC substantially reduced sheep losses at Hopland and required the removal of substantially fewer coyotes. Unfortunately for the Hopland facility and other sheep producers, the LPC recently became unavailable in California, thus insuring continuation of the challenging search for effective coyote predation management procedures (Timm and Connolly 2001).

## **OTHER LINES OF RESEARCH**

A number of other interesting and important lines of research have been explored by NWRC's predator

research group during the past decade. Marking agents of various types have proven to be an important means of studying coyote bait acceptance, as well as having utility as inert ingredients in pesticide and drug formulations, and potential forensic applications in hazard investigations. NWRC scientists continued to examine candidate materials and new approaches for their use in predation control research. New developments in remote recording equipment using radio telemetry or low light video are increasingly used to facilitate investigation of the behavior of individual coyotes. Techniques under development to identify individual coyotes and other species involved in livestock depredations include the use of genetic markers.

Experiments to identify new attractant strategies continue. Shivik and his collaborators at Colorado State University are investigating moving prey models to draw coyotes to traps or other devices. Jaeger and collaborators at the University of California are investigating coyote wariness and methods to selectively attract of adult territorial animals to particular locations using recorded vocalizations.

Use of livestock guarding animals continues to expand and we have continued to evaluate applications. In collaboration with the Berryman Institute at Utah State University we recently determined that llamas could indeed be effective livestock guards in fenced pastures. We examined behavioral traits and physical characteristics that could predict the probable success of individual llamas (Cavalcanti and Knowlton 1998).

Development of techniques for estimating coyote populations, assessing movement patterns, or indexing activity continue to be important areas of research, particularly with the need for such data for environmental assessments to analyze the potential population effects of predation management programs (Henke and Knowlton 1995). Development of a predictive model incorporating coyote population dynamics and behavioral data to assess the impact of various control strategies, and development of economics models to assess costs of management options may offer new tools for wildlife managers handling coyote predation issues (Pitt et al. 2000).

In many areas, managers are attempting to apply the techniques of predation management in agriculture to the complex problems of endangered species recovery and stabilizing resident game populations in increasingly limited and fragmented habitats. Although no direct funding has been available to support research efforts, NWRC scientists are assisting other state and federal agencies on a number of such problems (Mason et al. 2001).

Surveillance, monitoring, or development of management techniques for wildlife-borne diseases, particularly rabies, has added an additional dimension to the NWRC research program in the past decade. And, the increasing limitations on the use of other predation management tools has made analysis of the effectiveness of aerial operations for managing predation or wildlife disease epidemics an issue of continuing concern.

## DISCUSSION

The human-wildlife interface is increasing worldwide, generating a host of new wildlife management problems and new research needs to challenge wildlife scientists (Bruggers et al. *In Press*). Predation management, always a contentious issue, continues to be faced with the loss of effective management tools – and, as in the past, with more questions than answers. But at the same time, demands for new management strategies and adaptation of existing technology to new problems continue to increase.

A major review and synthesis of information on coyote demographics, factors influencing livestock depredations, and the techniques available to wildlife managers and landowners was recently published by NWRC scientists, stimulated by continuing misinformation in the popular press about livestock predation problems (Knowlton et al. 1999). The paper concludes that predation management requires the integrated use of available techniques and a partnership among producers and wildlife managers to resolve livestock predation problems as effectively, efficiently, and economically as possible and in the least intrusive and most benign ways. A recently published program-wide audit of Wildlife Services by the General Accounting Office (2001) reached a similar conclusion. While this integrated approach will likely continue to be the “strategy of the future,” the need for new tools and techniques to apply in ecologically-based, integrated management programs and the need for new ways to assess and monitor program effects will continue to provide challenges.

With new facilities for predator research available at NWRC field stations and at NWRC’s new Colorado State University campus, and with new, dedicated funding for predator control research provided during the last federal budget cycle, the next decade will continue to provide exciting opportunities for problem solving research and continue to attract talented scientists to this challenging field of wildlife damage management.

## ACKNOWLEDGEMENTS

This paper briefly summarizes the work of a number of researchers at USDA/APHIS Wildlife Services National Wildlife Research Center and their students, cooperators, and colleagues at other institutions. We are grateful to these scientists, and particularly to the predator research project leaders who served during the decade. In addition to Russ Mason, these include: T. J. DeLiberto, E. M. Gese, M. M. Jaeger, F. F. Knowlton, S. B. Linhart, R. D. Nass, H. P. Pan, R. L. Phillips, and J. A. Shivik, all of whom helped provide us the background and information to prepare this summary. NWRC publications are available at [www.aphis.usda/ws/nwrc](http://www.aphis.usda/ws/nwrc).

## LITERATURE CITED

ANDELT, W. F., R. L. PHILLIPS, K. S. GRUVER, and J. W. GUTHRIE. 1999. Coyote predation on domestic sheep deterred with electronic dog-training collar. *Wildl. Soc. Bull.* 27(1):12-18.

BALSER, D. S. 1964. Management of predator populations with antifertility agents. *J. Wildl. Manage.* 28(2):352-358.

BALSER, D. S. 1965. Tranquilizer tabs for capturing wild carnivores. *J. Wildl. Manage.* 29(3):438-442.

BALSER, D. S. 1974. A review of coyote control research. *Proc. Vertebr. Pest Conf.* 6:171-177.

BLEIWAS, K. M., B. N. SACKS, M. M. JAEGER, and D. R. MCCULLOUGH. 2002. The effectiveness of selective removal of breeding coyotes in reducing sheep predation. *J. Wildl. Manage.* 66(2):451-462.

BODENCHUK, M. J., J. R. MASON, and W. C. PITT. *In Press*. Economics of predation management in relation to agriculture, wildlife, and human health and safety. *In: L. Clark (ed.), Economics of Wildlife Damage*. Colorado State University, Fort Collins.

BROMLEY, C., and E. M. GESE. 2001a. Effects of sterilization on territory fidelity and maintenance, pair bonds, and survival rates of free-ranging coyotes. *Can. J. Zool.* 79:386-392.

BROMLEY, C., and E. M. GESE. 2001b. Surgical sterilization as a method of reducing coyote predation on domestic sheep. *J. Wildl. Manage.* 65(3):510-519.

BRUGGERS, R. L., R. OWENS, and T. HOFFMAN. *In Press*. Wildlife damage management research needs: perceptions of scientists, wildlife managers, and stakeholders of the USDA-Wildlife Services program. *Int. Biodeterior. & Biodegrad.*

BURNS, R. J., and J. R. MASON. 1996. Effectiveness of Vichos non-lethal collars in deterring coyote attacks on sheep. *Proc. Vertebr. Pest Conf.* 17:204-206.

CAVALCANTI, S. N. C., and F. F. KNOWLTON. 1998. Evaluation of physical and behavioral traits of llamas associated with aggressiveness toward sheep-threatening canids. *Appl. Anim. Behav. Sci.* 61:143-158.

CONNER, M. M., M. M. JAEGER, T. J. WELLER, and D. R. MCCULLOUGH. 1998. Effect of coyote removal on sheep predation in northern California. *J. Wildl. Manage.* 62(2):690-699.

CONNOLLY, G. E., R. E. GRIFFITHS, JR., and P. J. SAVARIE. 1978. Toxic collar for control of sheep-killing coyotes: a progress report. *Proc. Vertebr. Pest Conf.* 8:197-205.

CONNOLLY, G. E., R. M. TIMM, W. E. HOWARD, and W. M. LONGHURST. 1976. Sheep-killing behavior of captive coyotes. *J. Wildl. Manage.* 40(3):400-407.

CONOVER, M. R., R. D. DEUSER, F. F. KNOWLTON, and J. A. CHAPMAN. 1991. Utah State University’s academic program in wildlife damage management. *Proc. Gt. Plains Wildl. Damage Control Workshop* 10:148-152.

CURNOW, R. D. 1996. Introducing the National Wildlife Research Center. *Proc. Vertebr. Pest Conf.* 17:6-7.

DELIBERTO, T. J., E. M. GESE, F. F. KNOWLTON, J. R. MASON, M. R. CONOVER, L. MILLER, R. H. SCHMIDT, and M. K. HOLLAND. 1998. Fertility control in coyotes: is it a potential management tool? *Proc. Vertebr. Pest Conf.* 18:144-149.

FALL, M. W. 1990. Control of coyote predation on livestock—progress in research and development. *Proc. Vertebr. Pest Conf.* 14:245-251.

- FALL, M. W. 2002. The search for acceptable animal traps. *Proc. Vertebr. Pest Conf.* 20:371-377.
- GENERAL ACCOUNTING OFFICE. 2001. Wildlife Services Program – Information on Activities to Manage Wildlife Damage, Report to Congressional Committees. GAO-02-138. U.S. General Accounting Office, Washington, D. C. 70 pp.
- HALSTEAD, T. D., K. S. GRUVER, R. L. PHILLIPS, and R. E. JOHNSON. 1996. Using telemetry equipment for monitoring traps and snares. *Proc. Gt. Plains Wildl. Damage Control Workshop* 12:121-123.
- HARRIS, C. E., and F. F. KNOWLTON. 2001. Differential responses of coyotes to novel stimuli in familiar and unfamiliar settings. *Can. J. Zool.* 79:2005-2013.
- HENKE, S. E., and F. F. KNOWLTON. 1995. Techniques for estimating coyote abundance. Pp. 71-78 in D. Rollins, C. Richardson, T. Blankenship, K. Canon, and S. Henke (eds.), *Proc. Symp. on Coyotes in the Southwest: A Compendium of Our Knowledge*. Texas Parks and Wildlife Department, Austin.
- JAEGER, M. M., K. M. BLEJWAS, B. N. SACKS, J. C. C. NEALE, M. M. CONNER, and D. R. MCCULLOUGH. 2001. Targeting alphas can make coyote control more effective and socially acceptable. *Calif. Agric.* 55(6):32-36.
- KIMBALL, B. A., J. R. MASON, F. S. BLOM, J. J. JOHNSTON, and D. E. ZEMLICKA. 2000. Development and testing of seven new synthetic coyote attractants. *J. Agric. Food Chem.* 48(5):1892-1897.
- KNOWLTON, F. F. 1972. Preliminary interpretations of coyote population mechanics with some management implications. *J. Wildl. Manage.* 36(2):369-382.
- KNOWLTON, F. F. 1989. Predator biology and livestock depredation management. *Proc. West. Sect., Amer. Soc. Anim. Sci.* 40:504-509.
- KNOWLTON, F., E. M. GESE, and M. M. JAEGER. 1999. Coyote depredation control: an interface between biology and management. *J. Range Manage.* 52(5):398-412.
- KNOWLTON, F. F., L. A. WINDBERG, and C. E. WAHLGREN. 1985. Coyote vulnerability to several management techniques. *Proc. Gt. Plains Wildl. Damage Control Workshop* 7:165-176.
- LINHART, S. B. 1984. Managing coyote damage problems with nonlethal techniques. *Proc. East. Wildl. Damage Conf.* 1:105-118.
- LINHART, S. B., H. H. BRUSMAN, and D. S. BALSER. 1968. Field evaluation of an antifertility agent, stilbestrol, for inhibiting coyote reproduction. *No. Am. Wildl. Nat. Resour. Conf.* 33:316-327.
- LINHART, S. B., and G. J. DASCH. 1992. Improved performance of padded jaw traps for capturing coyotes. *Wildl. Soc. Bull.* 20(1):63-66.
- LINHART, S. B., G. J. DASCH, R. R. JOHNSON, J. PACKHAM, and J. D. ROBERTS. 1992. Electronic frightening devices for reducing coyote predation on domestic sheep: efficacy under range conditions and operational use. *Proc. Vertebr. Pest Conf.* 15:386-392.
- LINHART, S. B., A. KAPPELER, and L. A. WINDBERG. 1997. A review of baits and bait delivery systems for free-ranging carnivores and ungulates. Pp. 69-132 in T. J. Kreeger (ed.), *Contraception in Wildlife Management*. USDA Tech. Bull. No. 1853, USDA, Washington, D.C. 272 pp.
- LINHART, S. B., R. T. STERNER, G. J. DASCH, and J. W. THEADE. 1984. Efficacy of light and sound stimuli for reducing coyote predation upon pastured sheep. *Protect. Ecol.* 6:75-84.
- MASON, J. R., J. L. BELANT, A. E. BARRAS, and J. W. GUTHRIE. 1999. Effectiveness of color as an M-44 attractant for coyotes. *Wildl. Soc. Bull.* 27(1):86-90.
- MASON, J. R., and S. BLOM. 1998. Coyote lure ingredients: what factors determine success? *Wildl. Control Tech.* 5(5):26-30.
- MASON, J. R., and R. J. BURNS. 1997. Coyote responsiveness to novel visual stimuli. *J. Wildl. Res.* 2:6-8.
- MASON, R. J., R. A. DOLBEER, and G. PRETI. 1999. Naturally-occurring odoriferous animal repellent (U.S. Patent #5,887,223).
- MASON, J. R., and J. A. MCCONNELL. 1997. Hedonic responsiveness of coyotes to 15 aqueous taste solutions. *J. Wildl. Res.* 2:21-24.
- MASON, J. R., J. A. SHIVIK, and M. W. FALL. 2001. Chemical repellents and other aversive strategies in predation management. *Endangered Species Update* 18(4):175-181.
- MILLER, L. A. 1995. Immunocontraception as a tool for controlling reproduction in coyotes. Pp. 172-176 in: D. Rollins, C. Richardson, T. Blankenship, K. Canon, and S. Henke (eds.), *Symp. on Coyotes in the Southwest: A Compendium of Our Knowledge*. Texas Parks and Wildlife Department, Austin.
- NEALE, J. C. C., B. N. SACKS, M. M. JAEGER, and D. R. MCCULLOUGH. 1998. A comparison of bobcat and coyote predation on lambs in north-coastal California. *J. Wildl. Manage.* 62(2):700-706.
- PHILLIPS, R. L., and F. S. BLOM. 1994. Field evaluation of chemical attractants for summer use on M-44s. *Proc. Vertebr. Pest Conf.* 16:51-56.
- PHILLIPS, R. L., and K. S. GRUVER. 1996. Performance of the Paws-I-Trip™ pan tension device on 3 types of traps. *Wildl. Soc. Bull.* 24(1):119-122.
- PHILLIPS, R. L., and C. MULLIS. 1996. Expanded field testing of the No. 3 Victor Soft Catch® trap. *Wildl. Soc. Bull.* 24(1):128-131.
- PITT, W. C., F. F. KNOWLTON, A. OGAWA, and P. W. BOX. 2000. Evaluation of depredation management techniques for territorial animals using a computer model: coyotes as a case study. *Proc. Vertebr. Pest Conf.* 19:315-318.
- REED, N. P. 1972. Views of the Department of Interior. *No. Am. Wildl. Nat. Resour. Conf.* 37:402-406.
- ROLLINS, D., C. RICHARDSON, T. BLANKENSHIP, K. CANON, and S. HENKE (EDITORS.). 1995. *Symp. on Coyotes in the Southwest: A Compendium of Our Knowledge*. Texas Parks and Wildlife Department, Austin. 180 pp.
- SACKS, B. N., K. M. BLEJWAS, and M. M. JAEGER. 1999a. Relative vulnerability of coyotes to removal methods on a northern California ranch. *J. Wildl. Manage.* 63(3):939-949.

- SACKS, B. N., M. M. JAEGER, J. C. C. NEALE, and D. R. McCULLOUGH. 1999b. Territoriality and breeding status of coyotes relative to sheep predation. *J. Wildl. Manage.* 63(2):593-605.
- SACKS, B. N., and J. C. C. NEALE. *In Press*. Foraging strategy of a generalist predator toward a special prey: coyote predation on sheep. *Ecol. Appl.*
- SCHMIDT, R. H., M. R. CONOVER, R. D. DUESER, F. F. KNOWLTON, and T. A. MESSMER. 1992. Training tomorrow's specialists in wildlife damage management. *Proc. East. Wildl. Damage Control Conf.* 5:216-217.
- SHIVIK, J. A. 2001. The other tools for wolf management. *Wolf!* 19(2):3-7.
- SHIVIK, J. A., K. S. GRUVER, and T. J. DELIBERTO. 2000. Preliminary evaluation of new cable restraints to capture coyotes. *Wildl. Soc. Bull.* 28(3):606-613.
- SHIVIK, J. A., and D. J. MARTIN. 2001. Aversive and disruptive stimulus applications for managing predation. *Proc. Wildl. Damage Manage. Conf.* 9:111-119.
- TILL, J. A., and F. F. KNOWLTON. 1983. Efficacy of denning in alleviating coyote depredations upon domestic sheep. *J. Wildl. Manage.* 47(4):1018-1025.
- TIMM, R. M., and G. E. CONNOLLY. 2001. Sheep-killing coyotes a continuing dilemma for ranchers. *Calif. Agric.* 55(6):26-31.
- WINDBERG, L. 1996. Coyote responses to visual and olfactory stimuli related to familiarity with an area. *Can. J. Zool.* 74:2248-2253.
- WINDBERG, L. A., and F. F. KNOWLTON. 1988. Management implications of coyote spacing patterns in southern Texas. *J. Wildl. Manage.* 52(4):632-640.
- WINDBERG, L. A., and F. F. KNOWLTON. 1990. Relative vulnerability of coyotes to some capture procedures. *Wildl. Soc. Bull.* 18(3):282-290.
- ZEMLICKA, D. E., and J. R. MASON. 2000. Response of captive coyotes to Renardine coyote repellent. *Proc. Vertebr. Pest Conf.* 19:336-338.
- ZEMLICKA, D. E., D. P. SAHR, P. J. SAVARIE, F. F. KNOWLTON, F. S. BLOM, and J. J. BELANT. 1997. Development and registration of a practical tranquilizer trap device (TTD) for foot-hold traps. *Proc. Gt. Plains Wildl. Damage Control Workshop* 13:42-45.

